Notes on the Kanmantoo-Strathalbyn Mining District

Compiled by G.J. Drew

2014
INTRODUCTION

AUSTRALIA’S FIRST MINING ERA

During the period 1841-1851, the Mount Lofty Ranges were the site of Australia’s first mining era. This was the decade prior to the discovery of gold in the eastern States when virtually all of the metalliferous mines in Australia were located in South Australia and whose population grew, as a result, from 15,000 in 1841 to 64,000 in 1851.

The 1840s mining boom followed the discovery of silver-lead ore at Glen Osmond, in the foothills of the Mount Lofty Ranges on the outskirts of Adelaide. The Glen Osmond discoveries were quickly followed by the discovery and exploitation of a large number of mines, the most significant being the copper deposits at Kapunda (1844) and Burra (1845). These developments came at a crucial time in the history of South Australia; in the early 1840s the newly created colony was on the verge of bankruptcy and was saved from collapse by the mining boom.

The mining of copper ores at Kapunda and Burra caused the first major decentralisation away from Adelaide and by 1850, Burra with a population of 5000 was the largest inland town in Australia and seventh largest overall. In 1850, minerals constituted 67% of the value of exports from the Colony and wool 29%. A large proportion of the population was directly or indirectly dependent on mining and South Australia was the third largest copper producer in the world.

These mineral deposits, the first exploited less than five years after first settlement of the Colony, had a profound effect on settlement. They brought about a major influx of capital and immigrants into the Colony after the depression of the early 1840s and provided employment for a large number of people. Land was surveyed for mineral tenements, mining townships and agricultural purposes. Basic road networks were established during this period to cart ore to Port Adelaide for shipment to Wales and also deliver heavy machinery to the mines.

Mines of Australia’s First Mining Era. PIRSA Plan 1986-0343
THE FIRST DISCOVERIES

**Glen Osmond**
The first metalliferous mine in Australia, Wheal Gawler, commenced operations within sight of Adelaide in 1841. Land at Glen Osmond had been surveyed into sections and sold in the late 1830s and, according to the existing Land Sale Regulations, mineral rights belonged to the land owners. The Glen Osmond mines were small, employing up to 200 people at one time, but they were the first to attract Cornish miners as settlers to South Australia. Mining ceased by 1851 partly due to the exodus of miners to the newly discovered Victorian goldfields.

**Kapunda**
In 1842, Francis Dutton and Captain Charles Bagot jointly discovered copper on unsurveyed Crown land near the present town of Kapunda. Very little land outside the Adelaide area had been surveyed and sold at that time and the 1842 Act for the Sale of Waste Land of the Crown stipulated that such land had to be sold at auction in 80 acre lots at a minimum price of £1 per acre. Keeping their discovery a secret, Captain Bagot requested an 80 acre section be surveyed around the outcrop, and put in a tender of £80 which was accepted in January 1843. This section became the Kapunda Mine which in due course made Bagot and Dutton wealthy.

Mining operations commenced in January 1844 and by 1846, several rows of miners' cottages had been constructed on the mining property, the first company housing in Australia. In 1845, the first horse whim in the Colony was erected to drain water from the mine but it was incapable of handling the volume and in 1848, the first Cornish beam engine in Australia was erected. By 1850, the mine employed 300 men and boys and copper to the value of nearly £1 million was produced up to closure in 1879.

**SPECIAL MINERAL SURVEYS**
Following the discovery of copper on Crown land at Kapunda and its subsequent survey and purchase for £80, regulations originally issued in 1842 stipulating that the minimum amount of land that could be purchased in unsurveyed districts was 20,000 acres at one pound per acre, were brought into force. This became, therefore, the only way to acquire mineral rights on unsurveyed Crown land after 1844. Four such special (or monster) surveys were made and purchased before the system was abolished in 1851: Burra Creek (1845), Mt. Barker (1845), Mt. Remarkable (1846) and Reedy Creek (1846).
Burra Creek Special Survey

The first discoveries of minerals outside the surveyed districts were near Burra Burra Creek in 1845, by two shepherds at two separate localities. To acquire the mineral rights, the Burra Creek Special Survey was jointly purchased in late 1845 by two parties that were formed to raise the sum of £20,000. These parties were the South Australian Mining Association (SAMA) and the Princess Royal Mining Company (PRMC).

After purchase, the survey, measuring 8 miles by 4 miles was laid out to incorporate the two discoveries, one in each half and lots were drawn to determine ownership of the two halves. SAMA gained the northern half and what was to become the Burra Burra Mine. PRMC won the southern half and what was considered to be the more impressive outcrop but the ore quickly petered out at depth and operations at the Princess Royal mine ceased in 1851.

Mining commenced at the Burra Burra mine in September 1845. It was soon to become the largest mine in Australia and produced 80,000t of dressed ore up to 1851 with peak production of 23,000t in 1851 which was about 5% of the world’s copper production. Its orebody was so rich that it was referred to as the Monster Mine and the Eighth Wonder of the World and during its first six years of operation issued 15 dividends of 200%. More than 1000 men and boys were employed on the mine and a further 1000 were employed as carters, woodcutters and smelter men.

Mt. Remarkable Special Survey

After a report that a hill of copper had been seen at the head of Spencer Gulf a special survey of 20,000 acres was applied for and granted in May 1846 to the Mt. Remarkable Mining Company. However, the company proved unsuccessful and was dissolved in 1851. In 1852, the townships of Bangor and Melrose were laid out at the southern and northern ends of the survey, respectively, and sold with the remainder of the company property at auction in January 1853.

Reedy Creek (Tungkillo) Special Survey

This survey of 20,000 acres was purchased in September 1846 by the Australian Mining Company to acquire mineral rights to a copper discovery in the vicinity of Reedy Creek, 50km east of Adelaide. Operations commenced at the Tungkillo Mine in 1847 and Cornish miners and captains were brought to the Colony by the company to work the mine. In 1849, the company surveyed a mining township on its land near the mine. The township, named Southend, had a population of 600 people at its peak in 1850 but was virtually abandoned when the mine closed in 1851.

Mount Barker Special Survey

In 1845, encouraged by reports of mineralisation in the Mount Lofty Ranges, the South Australian Company sent two Cornish miners to explore the Mount Barker district. The South Australian Company was a private joint-stock company formed in England in 1836; although the main aim of the company was to encourage investment in commerce, shipping, land, livestock and building in South Australia, it also kept in mind the possibility of investment in mining. The Cornishmen reported to the company's secretary in South Australia, William Giles that they had found a rich deposit of copper ore, and this was confirmed by the company's geologist, J.C. Dixon. The company directors in England instructed Giles to purchase the freehold of the land, and accordingly, Giles applied to the Treasury for the area he wanted.

Giles' application was refused as an earlier application for a part of the land had already been granted to Duncan and Lachlan MacFarlane of Mount Barker, who wanted the land for grazing their sheep. The South Australian Company was not accustomed to being thwarted and sought the intervention of the newly-arrived Governor Robe on their behalf. However, the MacFarlane brothers, who were by now undoubtedly well aware of the mineral find, refused to give way to the South Australian Company and were supported by a group of influential Adelaide men. Eventually a compromise was reached when the two parties agreed to make a combined application for a special survey of 20,000 acres at the regulation price of £1 an acre. Robe agreed to this and the MacFarlanes, together with their financial supporters, formed the Paringa Mining Company with sufficient capital to purchase 8000 acres, with the South Australian Company to purchase the balance of the 20,000 acres.

The survey took place in January 1846 and the two companies agreed to divide the survey into 20 strips, each of 1000 acres, and to select one strip at a time, with the choice of the first strip decided by drawing lots. The South Australian Company won the right to first choice and selected strip 5, which was described in a newspaper report as containing a most magnificent lode of great extent, with innumerable smaller lodes... and fully bearing out the official report that the whole survey was a field of copper.
The MacFarlane group’s first choice was strip 4, in all respects similar to the first choice. The South Australian Company chose the name Kanmantoo for their mine while the MacFarlane group’s orebody became the Paringa Mine.

Mining commenced at Kanmantoo in 1846 and by 1850, a number of other mines had been established, most bearing the names of famous Cornish mines including Wheal Prosper, Wheal Friendship, Wheal Mary, Wheal Harmony and Wheal Maria. The most important mines were Kanmantoo, Paringa (1846) and Bremer (1850). The companies divided their land into mining sets in the Cornish fashion and offered them for lease. By 1850, the mining townships of St. Ives (1846), Kanmantoo (1849) and Callington (1850) had been laid out by the companies to serve the nearby mines. Other townships surveyed were Tavistock and Staughton in 1846, and Kanmantoo South in 1857. St. Ives, and Callington were named after famous Cornish towns. Within this Cornwall of the colony, as the local press dubbed it, were Cornish settlers - miners and their families and others - who brought their social and cultural influence to bear within in the district.

LATER MINES

The end of Australia’s first era in 1851 also saw the end of the Special Mineral Surveys which resulted in the Burra Mine and mines in the Kanmantoo-Callington district. Other early mines in the Adelaide Hills required land to be purchased as 80 acre sections to acquire the mineral rights (eg. the Strathalbyn Mine). In 1851, the first regulations were issued for mining leases and gold mining on Crown land. However much of the Adelaide Hills was privately owned and hence the mineral rights belonged to the landowners. As a result mines were established by agreement with landowners usually by payment of a royalty of the value of all minerals raised. Examples of mines worked under this arrangement include the Worthing and Aclare,
GEOLOGY OF THE ADELAIDE HILLS

The Mount Lofty Ranges are comprised of rocks of the Proterozoic Barossa Complex and Adelaidean System and the Cambrian Kanmantoo Group. Metamorphic rocks of the Barossa Complex have a minimum age of about 1600 million years and occur as “windows” in the younger Adelaidean System which was deposited as sediments in an elongate basin known as the Adelaide Geosyncline, active from about 800 million years ago. Sedimentation in the Adelaide Geosyncline ceased about 570 million years ago when the eastern margin began to subside rapidly forming the Kanmantoo Trough which runs in an arc around the eastern side of the Mount Lofty Ranges. As it subsided it filled with sediments which during subsequent earth movements were converted to metamorphic rocks.

About 500 million years ago, major earth movements (the Delamerian Orogeny) converted the sediments of the Adelaide Geosyncline and Kanmantoo Trough into a north-south mountain range over a period of about 50 million years. The area was then subjected to a period of extensive weathering and erosion which lasted some 400 million years and converted the mountain range to a generally flat landscape (penepain) by the beginning of the Tertiary period, about 60 million years ago.

During the early Tertiary, old faults became active again, disturbing the flat landscape and forming the present day Mount Lofty Ranges as a series of uplifted fault blocks. As a result of these movements certain areas began to subside forming basins in which sediments accumulated (e.g. Adelaide, Noarlunga and Willunga Basins). Sedimentation was initially from freshwater streams draining the surrounding highlands but later the sea covered low lying areas and marine sediments were deposited.

Further block faulting in the mid-Tertiary accentuated the horsts and grabens and initiated further extensive erosion of the uplifted blocks (horsts) with the sediments being transported to low lying areas such as the Meadows Basin where sand and gravel (along with gold) were deposited in ancient lakes and river valleys about 10 to 15 million years ago.

About two million years ago, further uplift along the old fault lines resulted in a period of erosion which has continued to the present day. Vigorous erosion associated with this uplift has produced deeply incised valleys and gorges (e.g. Sturt and Onkaparinga Gorges). The present relief is generally rounded with flat topped ridges which formed part of the pre-Tertiary erosional surface before block faulting and erosion brought about dissection.

Simplified block diagram of the Adelaide Hills showing uplifted fault blocks and Tertiary basins
(from Talbot and Nesbitt, 1968)
Generalised geological plan of the Mount Lofty Ranges. PIRSA Plan 1978-0823
MINERAL DEPOSITS OF KANMANTOO-STRATHALBYN MINING DISTRICT

Silver-lead-zinc
Silver, lead and zinc occur as vein and stratiform deposits in metamorphosed rocks of the Kanmantoo Group in the Kanmantoo-Strathalbyn mineral field. The most significant silver-lead mine in the field was Aclare which produced about 14,500t of ore from 1859-1896. Wheal Ellen produced about 8000t of ore from 1857-1866 and 5000t of pyrite for sulphuric acid in 1908-1911. The ores at both mines contained a high content of zinc in the form of sphalerite which created significant difficulties in metal recoveries at a time before the invention of the flotation process. The Angas zinc-lead-silver deposit was discovered in 1991 and mining commenced in 2007 with annual production of 400,000t of ore expected to continue until about 2014.

Silver-lead veins (principally galena) also occur in Adelaidean sedimentary rocks. Australia’s first metalliferous mines were developed on outcrops of silver-lead ores in the foothills of the Mount Lofty Ranges at Glen Osmond in 1841. About 2500t of hand-picked ore was produced up to 1851. The Mount Malvern Mine (1859-1925) produced almost 2000t of silver-lead ore and 10,000 oz of silver were produced from the Almanda Mine (1868-1871).

Pyrite
Large reserves of pyrite occur in pyritic beds within the Kanmantoo Group. Between 1955 and 1972, open cut mining of pyrite at Brukunga produced more than 1Mt of concentrate from about 5.5Mt of pyritic ore. This has left a legacy of environmental problems with acidic drainage waters from the pyrite quarry, waste dumps and tailings dam. In 1977, the State Government accepted responsibility for rehabilitation of Brukunga and, in 1980, commissioned a lime neutralisation plant to treat acid water.

Copper
Copper is widespread as vein deposits in Kanmantoo Group metamorphic rocks which were prospected extensively from the mid-1840s. The most significant mines were in the Kanmantoo district: Kanmantoo (1845), Paringa (1846) and Bremer (1848). The largest of these was the Bremer Mine which produced about 35,000t of ore up to closure in 1875. The old Kanmantoo Mine was reworked in 1971-1976 when 4.5Mt of ore was produced by open cut mining and a new operation to expand the pit and produce a further 16Mt of ore will commence in 2011. The Tungkillo Mine produced 37,000t of copper-gold ore in five phases of operation from 1846-1971.

Historic Mines of the Adelaide Hills
MINES OF THE KANMANTOO-STRATHALBYN MINERAL DISTRICT

The Kanmantoo-Strathalbyn Mineral Field is located on the eastern flank of the Mount Lofty Ranges, approximately 50 km south-east of Adelaide. The deposits are hosted by rocks of the Kanmantoo Group, a sequence of metamorphosed sedimentary rocks of Cambrian age.

Geology of the Kanmantoo-Strathalbyn Mineral Field. PIRSA Plan 1981-0947
The development of Brukunga Mine was encouraged and sponsored by both the State and Federal Governments as part of the drive for self-sufficiency and full employment. The State Government fostered the formation of the company, Naime Pyrites Pty Ltd, a consortium of three fertiliser manufacturers and a mine operator: Cresco Fertilisers; Adelaide Chemical Company; Wallaroo-Mt Lyell Fertilisers; and BHP.

The mine commenced production in 1955 and continued for 17 years until 1972 when the Government withdrew the pyrite subsidy. The mine produced 5.5Mt of iron sulphide ore at 380,000t annually. The ore which averaged 11% sulphur, was crushed and concentrated onsite to 40% sulphur. The ore is a mix of two iron-sulphide minerals, these being pyrite and pyrrhotite. It was quarried from the side of two steep hills using a power shovel and trucks. The ore was concentrated by crushing and grinding to fine sand and the tailings were pumped to fill an adjacent shallow farm valley. The mine concentrate was trucked to a rail siding at Naime and then railed to Port Adelaide where it was converted to sulphuric acid. Imported phosphate rock was treated with the acid to produce superphosphate fertiliser to sustain the rapid expansion in agriculture.

**Environmental Concerns**

At closure the quarry bench was 1.8km long with two high walls 70 m and 85 m. Approximately 8Mt of overburden containing 2% sulphur had been excavated and discarded into two large rock-dumps and 3.5Mt of sand tailings containing 1.7% sulphur had been pumped to the adjacent valley.
The main environmental concern at Brukunga is caused by the natural oxidation of the iron minerals pyrite and pyrrhotite in air and water to form sulphuric acid drainage. The small amount of pyrite still remaining in the waste rock dumps and the tailings dam causes acid drainage to seep out at base of the dumps. The acid waters also dissolve small amounts of other metals from the minerals and the resultant seepage contaminates the flow in Dawesley Creek as the creek passes through the mine site. This results in acid metalliferous drainage from the site.

In August 1977, the State Government accepted responsibility for rehabilitation of Brukunga and the present rehabilitation strategy consists of:

- a treatment plant to collect and neutralise the acid drainage water
- a water monitoring program to identify the acid generation processes and their rate of change with respect to flow conditions at key sites within the area
- diversion of uncontaminated water directly into Dawesley Creek
- rehabilitation and revegetation of mine cuts, waste dumps and tailings dam.

The lime neutralisation plant commenced in 1980 and within five years of treatment the 10ha lake of acid water was removed from the tailings dam. The source of contaminated feed for the plant is made up of the seepage percolating through the tailings dam and from seepage collected by 12 float-activated pumps spread about the Mine site. Acid water is collected from the quarry bench, the waste rock dumps, and post-2003 from the section of creek bed isolated by the diversion drain. The collected water is held in two ponds located at the base of the tailings dam and pumped to the plant.

Despite all the work done from 1980 to 2003 to intercept and treat acid drainage only about half the contaminated water from the site was captured and treated, the remaining escaped to Dawesley Creek.

On completion of a diversion drain in June 2003, it became possible to intercept 90-95% of the contaminated water, with most of the loss occurring during high rainfall events, when there is greatest dilution helping to produce lower concentrations in the stream.

**The Lime Treatment Plant**
The inputs to the plant are hydrated lime, at pH 12, dilute sulphuric acid at pH 2.3 and oxygen provided by air blowers to ensure the chemical reactions are complete before the mix leaves the plant. The outputs are gypsum precipitate and water, which are physically separated in the thickener. The precipitate sinks to the bottom and is drawn from underneath by variable speed hose-pumps. The water overflows into the trough around the top of the tank. The overflow water is clarified in a large concrete lined pond, providing time for residual particles to settle before the water is returned to the creek via an open channel. The process of lime neutralisation occurs in a series of three mixing tanks providing retention time for completion of the chemical reactions. In May 2005, a second parallel series of three larger tanks were installed to effectively double the treatment capacity of the plant.

Grasses and native trees have been progressively established since 1988 in the thin layer of imported soil used to cover the once barren sand-tailings dam.

A whole of site remediation strategy is currently being developed to reassess the proposed third stage of the program. The South Australian Government’s overall remediation objectives for Brukunga include substantially limiting or avoiding the need to intercept and treat acid waters indefinitely; returning all or part of the site back to productive use(s) or for environmental / ecosystem values; and applying leading practice to site management and remediation options. Current projects include:

- A geochemical and geotechnical investigation into the waste rock dumps, tailings and natural borrow material to determine if there is suitable material on site that may be used as a cover material in any of the proposed remediation options.
- Waste rock dump trials, involving seven 1000t shaped waste rock piles receiving various treatments and irrigated to simulate rainfall to develop long-term management strategies for the waste rock and water.
CALLINGTON AND THE BREMER MINE

Callington
In late 1848, copper ore was discovered near the Bremer River in rock broken by the wheels of a dray. The land belonged to the Paringa Mining Company which mined the rich, shallow oxidised cap of the lode but then sold the land containing the mine to the Bremer Mining Company in 1849. The Paringa company, anticipating an increase in the mining population laid out the village of Callington adjacent to the Bremer Mine near where the new road from Adelaide crossed the Bremer River. It consisted of 196 allotments and a Police Reserve on either side of the river and was named after the famous Cornish town. Other mining villages surveyed in the district at this time were St Ives, Tavistock and Kanmantoo. The first settlers were predominantly Cornish miners who built small cottages of stone with shingle roofs, many of which survive making Callington a well-preserved mid-19th century mining township.

Although surveyed, the town was not officially named for some time and birth certificates listed the location as Bremer. The first hotel, the Callington Inn opened for business in 1851 when Thomas Lean was granted his publican’s licence. Very little work was done at the mine apart from some tributing and even that came to an end when the miners left for the Victorian goldfields. In 1856, the Paringa company (which had been reformed as the Britannia and Paringa Mining Company) auctioned off the unsold blocks in Callington and sold the Bremer Mine to the Worthing Mining Company.

Callington’s population reached a peak of 600 in the 1860s when the mine employed up to 140 men and the town had six stores, a bank and by 1867, a daily coach service to Adelaide. During this period there were three churches; Primitive Methodist (1851), Wesleyan Methodist (1852) and Lutheran (1864).
Bremer Mine
A copper lode was discovered near the Bremer River in 1848 and, by 1850, the mine was leased to the Bremer Mining Company. The mining township of Callington was surveyed around the mine for the expected increase in the mining population. Lack of capital prevented the installation of dewatering equipment and mining was restricted to several shafts sunk to the water table. About 450t of high grade ore were produced up to 1852 when work ceased due to the Victorian gold rush.

In 1856, the mine was sold to the Worthing Mining Company which transferred operations from the Worthing Mine near Hallett Cove. A 14-inch horizontal engine was installed in 1857 at Lean Shaft to enable mining operations to proceed below the water table. However, the engine was unable to cope with the water and a 60-inch Cornish pumping engine was erected at Leggs Shaft in 1859. This enabled the mine to be developed to the 103 fathom level over the next ten years.

Smelting works, consisting of two calcining and two reducing furnaces, were erected at the mine in 1859, and in the following year a 22-inch beam rotative engine was transferred to the Bremer Mine from the Worthing Mine (20km south of Adelaide) and used for hauling and to power crushing and ore-dressing machinery. Dressing machinery consisted of a stonebreaker, crushing rolls, self-acting plunger jiggers and a Bryans Rake buddle. The ore was hand-picked and the high grade crushed and sent direct to the nearby smelters and the low grade dressed to 15-50%. To overcome the problem in refining the ore caused by the presence of bismuth, the Scotts Creek Smelting Works at Dawesley was purchased in 1864 and used for refining the copper regulus from the Bremer smelter.

The mine reached a peak in 1866, when 140 men and boys were employed and about 350t of ore per month were produced. During this period the manager, Alfred Hallett, ran the mine with such efficiency that it was referred to as the model mine of South Australia. However, the company suspended operations in July 1870, due to the increased mining costs and falling copper prices, without a dividend having been paid.

The Bremer Mining Company reopened the mine in March 1872, under Captain Thomas Prisk, and after taking seven months to dewater the mine, operations consisted of extracting ore left by the previous company, mainly on the 93 and 103 fathom levels. New machinery powered by a 22-inch horizontal engine was erected in 1874 for crushing and concentrating the ore and a Hancock jig was added in 1872. The mine closed in 1875 after the known ore reserves had been removed. Total production of the Bremer Mine was about 35,000t of hand-picked copper ore averaging 8 to 10% copper.

In 1907, the Callington Mining Company attempted to reopen the mine but the new pumping equipment failed to lower the water below 21m and the mine was abandoned in the same year. During the early 1970s, the tailings dumps which remained from the dressing operations were treated by leaching and precipitation. Exploration was also conducted and included four diamond drill holes totalling 1300m which detected two mineralised pipe-like shoots. One drill hole intersected 23m at 1.1% copper below the Bremer Lode and the other intersected 53m at 0.24% copper below the Boundy Lode. This indicated a resource of 600,000t of ore at 1.1% copper below 240m. The site is listed on the Register of State Heritage Items.
Bremer Mine, c.1863. Legs engine house at left housed a 60-inch engine erected in 1859. The building to the left of the chimney housed the 22-inch engine transferred from the Worthing Mine in 1860. Note the pickey boys seated at the rear of the ore floor, in front of the shingle roofed structure. PIRSA photo 033235

Bremer Mine surface plan, c.1875. PIRSA plan 1991-0691.
Bremer Mine, c.1910. At left are the ruins of the pumping enginehouse with the Callington School at right.
PIRSA Photo 040122

Geology and Workings
The mine area lies in a NE trending belt of Kanmantoo Group schists. Two major copper lodes were worked: the Bremer and Boundy lodes. The Bremer Lode was 30-75cm wide, 110m long at the surface and dipped 70º west. A further ore shoot was found at the 53 fathom level north of the outcropping ore and persisted to the 103 fathom level. The Boundy Lode 100m to the east, was explored by drives from cross cuts from the main workings but was too low in grade for profitable mining. Oxides and carbonates were exploited to the 23 fathom level below which sulphides were encountered in a quartz-calcite lode.

Layout of the Cornish pumping enginehouse and windinghouse, Bremer Mine  PIRSA Plan 1991-0693
Wheal Ellen
Details of early operations at Wheal Ellen are sketchy; the mine apparently began under private ownership in early 1857, with a workforce of about one hundred men and produced 1500t of rich silver-lead ore in the first year of operation. By 1860, Cornish ore dressing machinery had been erected under the supervision of Captain Paynter and the mine had produced 2000t of carbonate ore and 2000t of sulphide ore. A blast furnace had also been erected. H.R. Hancock was engaged by the mine owners in 1859 and was responsible for mine management from 1861-1862. He later became famous as the manager of the Moonta Mine.

In 1861, the Wheal Ellen (South Australia) Mining Company Ltd. was formed in England and purchased the mine. The company erected a small horizontal steam engine for dewatering the mine and a calcining furnace and chimney. About 100 were employed during this period. By the end of 1862, the new furnace had been completed and the blast furnace rebuilt. However, the costs involved exceeded the income from production and the company was wound up in 1865. Production data are incomplete but, on the basis of available information, it is unlikely that more than about 8000t of silver-lead ore were produced at an overall grade of about 25% lead and about 20 oz/t silver. Gold was also recovered from both the sulphide ore and the gossan.

Wheal Ellen looking southeast, 1908. At the centre are the ruins of the pumping enginehouse and the tall chimney marks the site of the blast furnace. PIRSA Photo 034143

The Wheal Ellen Mining Co, formed in Adelaide in 1888, mined 40t of gold-bearing gossan before the mine was again closed in 1889. The property was acquired by the Commonwealth Silver-Lead Company Ltd. of Sydney in 1908 and worked until 1911. About 5000t of pyrite were mined for sulphuric acid production and a five-head stamp battery was erected and 404 oz of gold recovered from gossan and pyritic ore.

Geology and Workings
The Wheal Ellen orebody was an interbedded, tabular deposit 0.3-4.3m thick within micaceous sandstone which dips steeply to the east. The sulphide orebody consisted principally of pyrite, galena and sphalerite which was oxidised to a depth of 36m. The orebody was worked by five shafts over a length of about 230m and to a depth of 110m at the southern end. Recent exploration drilling has demonstrated the continuity of high grade poly-metallic mineralization with significant intersections up to 150m below the surface. It is shaping up as a resource that could support a third mine development in the area, following on from the Angas Mine and Kanmantoo Mine developments.

Ore Dressing
Cornish ore dressing machinery was erected about 700m south of the mine workings near a creek which would have supplied water required by the plant for most of the year. The machinery included Cornish stamps, buddles and probably mechanical jiggers. The chimney and foundations of the ore dressing plant and the boiler and engine which drove the machinery, as well as coarse tailings, survive on the bank above the creek. Higher still are the remains of the calcining furnace and a slag dump. Dressed sulphide ore was fired in the calcining furnace to drive off sulphur and other volatiles (including arsenic) prior to smelting in the blast furnace which was located about 400m to the north just below the mine workings.
An above ground flue running from the calciner is largely intact and ends in a distinctive labyrinth. The labyrinth was built to collect arsenic which was a common by-product of silver-lead ores and its design is derived from the processes adopted in Cornwall to treat these ores. It consists of a labyrinth of chambers built of slabs of stone in a zig zag arrangement where arsenious oxide condensed as soot. The labyrinth demonstrates the application of Cornish mining technology in 19th century South Australia and is listed on the Register of State Heritage Items. It is almost certainly the only one of its kind in Australia.

Angas Mine
The Angas zinc-lead-silver deposit which is seven km along strike from Wheal Ellen, was discovered in 1991 during an exploration program by Aberfoyle Resources Ltd. but was considered too small to be an economic mining proposition. Follow-up drilling by Terramin Australia Ltd. from 2004-2007 demonstrated probable ore reserves of 2.15Mt of ore grading 7.6% zinc, 2.9% lead, 0.2% copper, 31g/ t silver and 0.5g/ t gold, plus indicated and inferred resources of 0.53Mt grading 3.3% zinc, 1.6% lead, 0.1% copper, 20g/ t silver, and 0.4g/ t gold. Underground development commenced in July 2007 and ore production and first shipment of concentrates was achieved in July 2008. The ore is processed to produce a zinc concentrate and a lead-copper-gold-silver concentrate. The mine life is expected to be seven years, with ore production of 400,000t per year.

Economic mineralisation is contained within a garnetiferous host unit and extends approximately 700m along strike and 500m down dip. The width varies between less than 0.5m to 20m. Sphalerite, galena and chalcopyrite are associated with variable concentrations of pyrite and pyrrhotite. The ore occurs in three north-south oriented zones of mineralisation. The largest is Rankine with the smaller but higher grade Garwood along strike to the south. The orebody is shallow with the Rankine zone outcropping.

The Angas orebody is accessed through a portal at the bottom of a box-cut. A 5m by 5m decline provides access to the ore body, ramping down at 1:7 which will reach 2.8km from the portal. The orebody is mined using bench stoping with progressive fill. The rock is drilled and blasted from vertical stopes which are later backfilled for stability. The mine levels are 20 vertical metres apart and the current design depth is approximately 400m below surface. The majority of stope production is carried out using teleremote loading. Forty-tonne articulated dump trucks haul the ore to a surface stockpile ready for processing.
Aerial view of the Angas Mine open cut and treatment plant
Aclare Mine

Silver-lead ore was discovered on St. Ives Farm by the operators of Wheal Ellen and the first ore produced in 1859 from what later became known as the Aclare Mine. Although Aclare was the largest of the silver-lead mines in the district, with an estimated production of 14,584t of ore averaging 8.8% lead and 36 oz/t silver, it was a source of frustration to investors over a 40 year period. In addition to silver and lead, the ore had a high content of zinc and significant contents of arsenic, antimony and copper, all of which contributed to metallurgical difficulties in processing the ore.

The Wheal Ellen smelter was unable to cope with the complex Aclare ore and operations soon ceased. In the 1870s, the then landowner, Francis Singleton, employed a few miners to work the deposit on a small scale. Since the ore being mined at that stage was zinc-free lead carbonate it presented no difficulties in smelting and Singleton was able to make a small profit from the operation – the only time Aclare was to yield a profit.

Increasing metal prices in 1881 brought renewed enthusiasm and English capital to the South Australian mines, leading Singleton to float the Aclare Silver Mining Company N.L. in 1882. Mining work concentrated on developing adits to locate and extract the ore, but all were abandoned without achieving their aims. By 1883, the company was faced with serious difficulties: the price of silver had fallen as a consequence of increased exports of the metal from the USA, and the carbonate ore at Aclare was by then depleted, leaving the complex sulphide ore to be mined. The zinc content still presented problems in smelting the ore, making recovery of the silver and lead uneconomic. By 1884, the company was in financial difficulties, having spent most of its capital on the unproductive adits and being unable to sell the sulphide ore.

The spectacular success of the Broken Hill Mine led to renewed interest in abandoned silver-lead deposits in South Australia, including Aclare. A group of Adelaide investors formed the Aclare Silver-Lead Mining Syndicate in 1888 and purchased the mineral rights from Singleton. In the following year, the mineral rights were sold to an English company, the Kangarilla Proprietary Silver Mines of South Australia Ltd. The new company held high hopes for a smelting process developed by Haverman and Cunningham at Newcastle-on-Tyne for separating the silver and lead from the zinc but yet again this method was not able to economically treat the Aclare ore.

In 1891, D.D. Rosewarne, the former Inspector of Mines, was appointed to manage the company’s business interests in Australia. He promptly set about investigating ore processing techniques and was impressed by the potential of the Molesworth calcining furnace developed at the South Australian School of Mines. The Molesworth company agreed to build a furnace at their expense and Rosewarne had buildings erected for the concentrating plant and purchased equipment, including the French-made Castelnau concentrator, a 25hp horizontal steam engine, a 10hp beam engine and two large Cornish boilers. By late 1891, the prospects for Aclare at last looked promising, with a modern plant installed and the price of silver having risen, but the mood of optimism soon ended. The end of the year saw the Australian mining industry in a general depression due to falling metal prices, and operations at Aclare were brought to a standstill in February 1892 by a drought that deprived the mine of water for its operations. The company was also in serious financial difficulties because of overspending on the plant. Rosewarne resigned in March 1892 and the company was wound up in June.

A new company, the Kangarilla Silver Mines Ltd., was formed to take over the old company’s property and assets and to meet all its debts and liabilities. A trial in Glasgow with a two ton batch of Aclare ore, using a new leaching process developed by the metallurgists French and Stewart, was successful in extracting the metals and the company was convinced they had finally found the answer to treating the ore. A new Board was formed and H.G. Thorpe, an industrial chemist from Glasgow, was appointed to go to Aclare as mine manager and set up the French-Stewart process.

The first trial of the new furnace in May 1895 was disappointing: it was found that the existing crushing plant did not crush the ore to the size required by the French-Stewart process, leading to poor silver recovery. A new crushing plant was needed but the company had exhausted its capital and investors were not interested in providing further funds. The price of silver was still low and all interest was now in gold mining in Western Australia. The mine closed in 1896 and the company was wound up in 1899 and there has been no further mining at Aclare. The site is listed on the Register of State Heritage Items.
Geology
The mine area occurs in an area of Kanmantoo Group schists and quartzites. The orebody occurs in a 0.5-4m thick quartzite which outcrops on the top of the hill over a length of 60m. The ore consists of an aggregate of numerous folded layers of sulphide-rich and sulphide-poor quartzite, the main sulphides being galena and sphalerite. The layering in the ore is considered to be sedimentary in origin. Later metamorphism has deformed and recrystallised the original sulphide-rich sands to their present form. The orebody is tabular, dips 60-70º east and plunges south at about 40º on the eastern limb of a southerly plunging anticline. The ore horizon has been drag folded and the mine stopes follow the plunge of the drag fold. From the surface to a depth of 9m oxidation produced a carbonate ore depleted in zinc but enriched in lead and silver (av. 50% Pb and 90 oz Ag/t). Below the level of oxidation in the sulphide zone the ore averaged 12% Zn, 7% Pb and 20 oz Ag/t.

Workings
The mine was first worked from a series of shafts at the top of the hill. The main shaft was sunk to a depth of 79m, the first 30m being vertical and the remainder down the dip of the orebody. Near this shaft rich carbonate ore was extracted from an open cut to a depth of about 9m. Drivine and stoping from these shafts was carried out and high-grade ore was hauled by a horse whim. Later an adit was driven in a south-westerly direction from the northeast side of the hill above the level of the treatment plant for 250m to where the orebody was intersected and driven for about 80m. A considerable amount of work was carried out to a depth of about 35m below the adit level with ore hauled by windlass to adit level, loaded in trucks and pulled along the tramline to the treatment plant.
Ore Processing

Up to the early 1880s, the mine worked zinc free carbonate ore near the surface which was hand-picked at the surface, bagged and send to smelters at Port Adelaide where the lead and silver could be easily separated. Once sulphide ore was reached, zinc values increased but zinc could not be separated by smelting methods of the period.

In 1891, a new treatment plant was erected to treat the sulphide ore by initially crushing to separate grains of galena (lead sulphide) and sphalerite (zinc sulphide). The ore passed through a rock breaker and then Cornish rolls which crushed it to sand size. A classifier then separated the crushed ore into coarse sands (roughs) and finer slimes. The classifier was a settling tank with a sloping bottom and an agitation mechanism which allowed the roughs to settle to the bottom.

The roughs then passed to a jigger which was a box with a perforated bottom. The shaking action of the jigger caused the heaviest material in the mixture to sink to the bottom and pass through the perforations forming a concentrate. The overflow was run to the tailings dumps. Slimes from the classifier were fed to Castelnau Concentrator which consisted of an endless rubber belt about 8m long, 1.5m wide with a side slope, and distributed by water. Separation was apparently achieved by the speed of the belt, force of the jets and differences in specific gravity of the minerals.

In 1895, a brick furnace was erected to trial the French-Stewart leaching process. Finely crushed ore mixed with a flux was furnaced at red heat for 30 minutes with no stirring. It was then removed, allowed to cool and placed in a leaching vessel where lead, silver and zinc would be leached out and precipitated.

Aclare Mine ore treatment process, c.1895. PIRSA Plan 1980-0557
Kanmantoo Mine

The South Australian Company worked several pipe-like ore bodies down to depths of 60m. Ore dressed to grades of 25-30% copper was shipped to Swansea (Wales) for smelting and returned an average of about £15 per ton. Local smelting began in 1848, enabling treatment of ore with 12% copper, too poor for the Swansea market. In 1851 the South Australian Company, disappointed with the lack of profitability of the mine, decided to withdraw from mining and to concentrate on its pastoral activities.

There was little further activity on the mine until local syndicates took up leases in 1856 and produced small quantities of high grade ore. In 1861, the Kanmantoo Mining and Smelting Company was formed and initially worked the mine at a profit. Operations were suspended in 1865 due to a combination of scarcity of ore, falling copper price and lack of wood for smelting. In 1866, the New Kanmantoo Mining and Smelting Company took over the property and worked it continuously until 1874, although production and sales data suggest that it may have been profitable only in 1872. Limited prospecting activity was carried out in 1906-1907 and, in 1912, a small syndicate made an unsuccessful attempt to reopen one of the lodes. Total production from the mine in the period prior to World War I was 18,929t of ore averaging approximately 13% copper.

In the 1950s, Broken Hill South Ltd., aware that the future life of its mine at Broken Hill was limited, began an aggressive Australia-wide mineral exploration program through its subsidiary Mines Exploration Pty. Ltd. Investigations in the Kanmantoo district were commenced in 1962 and an induced polarization anomaly found over the hill containing the old Kanmantoo Mine. Subsequent diamond drilling of the anomaly indicated the existence of a mineable resource and in 1969 the decision was taken to develop an open pit mine by a new company, Kanmantoo Mines Ltd.

Mining commenced in 1971 and after returning profits in the financial years 1972-73 and 1973-74, the company suffered heavy losses in the following two financial years as a consequence of a dramatic fall in copper prices. Plans to develop an underground mine below the open pit were abandoned and the mine closed in June 1976 after having produced 4.05Mt of sulphide ore and 0.5Mt of oxidised ore at an average grade of 0.87% copper and 0.07g/ t gold. Hillgrove Resources Ltd began further exploration at the Kanmantoo Mine in 2004 and the company has proved up a resource of 32Mt grading 0.9% copper and 0.2g/ t gold. Production is planned to commence in late 2011.

**Hillgrove Resources Kanmantoo Mine layout, 2011.**
Paringa Mine
The Paringa Mining Company operated the mine from 1846 to 1851 in small workings on several lodes but was unprofitable throughout this period. A silver-lead lode was discovered on the property in 1847 but it too proved unprofitable. The only activity between 1851 and 1869 was the production of small parcels of ore from shallow prospecting workings.

In 1869, the New Paringa Mining Company reopened the mine and installed steam power to work the mine. A 35hp horizontal steam engine commenced operations in 1873 and a smelter was erected in the same year. However, insufficient payable ore was found and the mine closed again in 1874. A further attempt to reopen the mine in 1907 was also unsuccessful. Ore production from the Paringa mine was 972t averaging 21% copper, with the major part produced during the period of operation by the Paringa Mining Company. The site is now part of the new Kanmantoo Mine operated by Hillgrove Resources.
SMELTERS IN THE KANMANTOO STRATHALBYN DISTRICT

Between 1848 and 1874, 21 Welsh-style smelting works were erected in South Australia in the Mount Lofty and Flinders Ranges. By far the largest concentration was in the Kanmantoo Strathalbyn District where 7 works were erected, mainly in the Strathalbyn-Kanmantoo Mineral Field.

Bremer
The first commercially successful copper smelter in Australia was erected near Callington on the bank of the Bremer River in 1848. It was built by Cornishmen Mauris and John Thomas, who had smelting experience in Cornwall, Wales and Chile. A Welsh-style smelting furnace commenced smelting low-grade ore (12% copper) from the nearby Kanmantoo Mine using local timber as fuel. The ore was reduced to regulus (50% copper) in a single firing. Three further firings produced up to 95% copper. A blast furnace was introduced in late 1849. The Thomas brothers contracted with the South Australian Company but the smelter closed in 1852 when miners left for the Victorian goldfields.

Scotts Creek
These works were built by W. Dawes in 1857 near Scotts Creek, about 3km east of Nairne where wood and water were abundant. In 1858, the township of Dawesley was laid out around the smelting works. Operations commenced in June 1857 under the direction of R.V. Rodda treating ore from the Kanmantoo Mine and producing a regulus of 50 to 60% copper. In 1861, the Kanmantoo Mine and Scotts Creek Smelting Works were offered to the newly formed Kanmantoo Mining and Smelting Company. The works then consisted of calcining, reducing and refining furnaces capable of reducing 150t of ore per month, together with superintendent's residence, smelters' cottages, offices, smith's shop, weighbridge and ore sheds.

The works were sold to the Worthing Mining Company in May 1864 for £3000 to treat regulus from their Callington Smelter. In 1867, when a refinery capable of producing 98.5% copper commenced operations at Scotts Creek, regulus was no longer sold to the E&A Copper Company's works at Port Adelaide. Copper concentrate from the Balhannah Mine was treated at the Scotts Creek works between 1870 and 1876. Operations ceased in 1878.

Callington
The Thomas brothers erected a smelter in 1860 for the Worthing Mining Company near their Bremer Mine adjacent to the township of Callington. By 1861, the works consisted of one calcining and two smelting furnaces capable of reducing 60t of ore per week. Up to 1863, the regulus was sent to England for refining but between 1863 and 1867 it was sold to the E&A Copper Company. By 1868, the works consisted of two calcining and two smelting furnaces and regulus was sent to the Scotts Creek works for refining.

Wheal Ellen (see p. 16)

Kanmantoo Mine
The Kanmantoo Mining and Smelting Company decided to erect a new smelter on the mine following the sale of the Scotts Creek works in 1864. The company was reformed into the New Kanmantoo Mining and Smelting Company in 1866 and, in 1867, Thomas Mansell was appointed superintendent of the smelter. The new company worked the mine until 1874, supplying regulus to the E&A Copper Company between 1866 and 1873.

Paringa Mine
The Paringa Mine, first worked in 1846, was reworked by the Paringa Mining Company in 1870. Ore was sold to the Scotts Creek works until a smelter was erected at the mine in 1873. Between 1874 and 1880, 196t of regulus containing 48t of copper were sold to the E&A Copper Company. The smelter closed about 1880 but the slag heap still remains.

Nairne Creek
This smelter sold regulus and rough copper to the E&A Copper Company between 1871 and 1874. In 1866, the Nairne United Mining and Smelting Company's smelter was sold at auction to the West Kanmantoo Mining Company. Between May 1865 and October 1866, 129t of regulus were delivered from the Nairne United smelter to the E&A Copper Company.
Smelters in the Kanmantoo district. PIRSA Plan 1998-01269
REFERENCES and FURTHER READING


